United Nations ECE/TRANS/WP.15/2014/2

Economic and Social Council

Distr.: General
17 February 2014

Original: English

Economic Commission for Europe

Inland Transport Committee

Working Party on the Transport of Dangerous Goods

Ninety-sixth session
Geneva, 5-9 May 2014
Item 6 (a) of the provisional agenda
Construction and approval of vehicles

Use of Liquefied Natural Gas as fuel for vehicles carrying dangerous goods

Transmitted by the Government of the Netherlands[1]

Summary

Executive summary:	Amendments to Chapter 9.2 to make the use of Liquefied Natural Gas possible as fuel for vehicles carrying dangerous goods.
Action to be taken:	Amendment to subsections 9.2.4.3 and 9.2.4.4. of ADR.
Reference documents:	ECE/TRANS/WP.15/221 paragraphs 60 and 61 and informal documents INF.10, INF.23 and INF.25 of the ninety-fifth session.

[1] The present document is submitted in accordance with paragraph 1 (c) of the terms of reference of the Working Party, as contained in document ECE/TRANS/WP.15/190/Add.1, which provides a mandate to "develop and update the European Agreement concerning the International Carriage of Dangerous Goods by Road (ADR)".

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Introduction

1. In the November 2013 meeting of WP.15 (ninety-fifth session) the Netherlands presented informal document INF.10 containing an introduction to new fuels and proposals to amend Chapter 9.2 of ADR. In support of this document presentations were given concerning the use of liquefied natural gases (LNG) and the safety features included in the vehicle fuel systems. The presentations can be found as informal documents INF.23 and INF.25 of the ninety-fifth session.

2. Since the ninety-fifth session the amended ECE Regulation No. 110 (R110), containing the safety provisions for LNG fuel systems has been adopted during the 161st session of the World Forum for Harmonisation of Vehicle Regulations (WP.29) in November 2013. The entry into force is expected to be in June 2014.

3. The approval and entering into force of R110 will see Heavy Goods Vehicles fueled by LNG entering into service when ADR 2015 will be applicable (1 July 2015 to 1 July 2017). Compressed Natural Gas (CNG) fueled vehicles are already within the scope of the existing R110.

4. The Netherlands believes that it is very important that a harmonized and well founded position should be taken by all contracting parties to ADR, when it comes to allowing the use of LNG as fuel for the vehicle categories mentioned in Chapter 9.1. The Netherlands is also of the opinion that sufficient safety provisions are included in R110 to justify the use of LNG as fuel for heavy goods vehicles carrying Dangerous Goods and proposes to amend the wording in ADR accordingly. In order to reach consensus on the use of LNG for ADR 2015 the Netherlands proposes for the time being to limit adoption of alternative fuels to LNG only for AT, FL and OX vehicles, thus excluding EX vehicles and Mobile Explosive Manufacturing Units (MEMUs). For ease of acceptance the proposals for amendment are kept to a minimum.

5. Summary of the safety aspects of LNG fuel systems:

- LNG fuel tanks are double skinned. The space between is filled with "super" insulation (wound foil) and vacuum is applied. The inner and outer skin are made of austenitic stainless steel which is strong, pliable and has a high resistance to fire conditions.
- The fuel tank design is tested by dropping it from 9 meters on the most critical area (except the piping end) and from 3 meters on the piping end of the tank after which the tank shall remain tight. The tanks have a high resistance to accident damage.
- The fuel tank design is tested in fire conditions, the External fire (bonfire) test. The tank shall be completely engulfed in fire with a temperature of at least 590 °C. The tank shall not burst. A high resistance to fire conditions is proven. Even in the event of a loss of vacuum between the inner and outer skin of the fuel tank the contents shall discharge in a controlled manner to prevent bursting.
- Two systems of pressure relief are fitted in parallel. A primary pressure relief valve to remain within normal pressure/temperature conditions (boil-off) and a secondary pressure valve in case of accidental situations.
  The normal boil off is a limited volume vented high up behind the vehicle cab at a relative low pressure. Even in the case of a loss of vacuum this pressure relief is expected to cope. The risk (probability and effect) of this release of gas is very low. Future development may see this outflow contained or used otherwise to limit pollution.
  The discharge from the secondary (emergency) pressure release is also of a

relatively low pressure. This means that the discharged gas will remain at short distance to the valve, dispersing in the air quickly.

- When the engine stops, deliberately or in accidental situations an automatic closing valve on the tank will prevent the outflow of gas. The evaporator, fuel line and engine injection system have safety barriers to prevent unintended outflow of gas.
- The design of positive ignition systems used for LNG and CNG vehicles is of a different design than in the nineteen-nineties. Coils generating the high voltage will be on top of the sparkplugs or in close vicinity of the spark plugs and will be electronically triggered, so that risks of sparks by defective leads and electro magnetic pulses are limited in comparison to traditional systems in use when drafting Chapter 9.2 of ADR.
- Although natural gas is flammable at ambient pressure and temperatures, natural gas has a high auto ignition temperature (537 °C versus diesel at 210 °C[2]). The risk off ignition by a hot vehicle part is low. An overview of the physical properties of currently used vehicle fuels is shown in table 1 below. Because of the specific weight natural gas will be dispersed in the air quickly and the mixture will be below the lower explosion limit.

Table 1: physical properties (indicative) fuels

Fuel	*Specific Weight Liquid (g/L)*	*Specific weight Gas (g/L)*	*Flash Point*	*Lower Explosive Limit (LEL) – Upper Explosive Limit (UEL)*	*Auto ignition Temperature*
Petrol	700 at 20 °C	-	-43 °C	1.2% -7.1%	280 °C
Diesel	800 at 20 °C	-	55 °C	0.6%-7.5%	210 °C
LPG		20.0-20.67 at 0 °C -bar	-60 °C	1.8%-8.5%	287 °C
Ethanol	790 at 20 °C	-	17 °C	3.3%-19%	363 °C
Natural gas (methane)	422 at 162 °C	7.2 at 0 °C - 1bar	-188 °C	5%-15%	537 °C
Air		12.9 at 0 °C-1bar			

6. Comparison with Diesel fuel:

Tanks for diesel fuel are thin walled and commonly squared off. The design requirements are limited, only for fuel tanks made of plastic materials a bon-fire test is prescribed.

Diesel Fuel tanks offer limited protection against mechanical impact. When they rupture several hundred liters of diesel fuel may run out, forming a pool around the vehicle. Although the flashpoint is above 55 °C, the auto ignition point of diesel fuel is low at 210 °C. Touching hot vehicle parts may lead to ignition. When the diesel fuel ignites there will be sufficient fuel around to fuel exothermic reactions, which causes the vehicle (and its tires) to burn.

LNG tanks will stand up to mechanical impact and no release of fuel is expected. The fuel valve is closed automatically if the engine stops. No significant volume of fuel is available

[2] Although also higher auto ignition temperatures for diesel are reported, up to 280 °C.

to sustain a fire. Even in a fire condition the release of gas is limited. making it unlikely to result in a truck fire.

Proposal 1

7. Amend subsection 9.2.4.3 to read (new text in *italic* and underlined, replaced text stricken through):

"9.2.4.3 *Fuel tanks and fuel container*

The fuel tanks and fuel containers supplying the engine of the vehicle shall meet the following requirements:

(a) In the event of any leakage *in the normal operating conditions of the vehicle*, the fuel shall *not come* ~~drain to the ground without coming~~ into contact with hot parts of the vehicle or *of* the load;

(b) *Fuel tanks for liquid fuels shall comply with ECE Regulation No. 34.* Fuel tanks containing petrol shall be equipped with an effective flame trap at the filler opening or with a closure enabling the opening to be kept hermetically sealed;

(c) Fuel tanks for liquefied natural gas (LNG) shall comply with the provisions of ECE Regulation No. 110. Additionally the discharge of the (emergency) pressure relief devices shall be so directed to avoid any danger to the load through heating or ignition;

(d) Fuel containers for Liquefied Petroleum gas (LPG) and Compressed natural gas (CNG) shall not be applied. ".

Proposal 2

8. Amend Subsection 9.2.4.4 (new text in *italic* and underlined) to read:

9.2.4.4 *Engine*

The engine propelling the vehicle shall be so equipped and situated to avoid any danger to the load through heating or ignition. In the case of EX/II and EX/III vehicles the engine shall be of compression-ignition construction *using only fuels with a flashpoint above 55 °C*.

Proposal 3

9. Introduce new transitional measures to read:

"1.6.5.xx

EX/II, EX/III, FL and OX vehicles registered before 1 July 2015, fitted with fuel tanks not approved according to ECE Regulation No. 34 may still be used."

"1.6.5.xy

FL and OX vehicles registered before 1 July 2015, fitted with a LNG fuel system, not fully in compliance with ECE Regulation No. 110, may still be used with the approval of the competent authority of the country of registration, if an equal level of safety can be demonstrated."

Combustion heaters

10. Combustion heaters shall comply with ECE Regulation No. 122. In this regulation LPG and CNG are included as gaseous fuels. However where additional safety regulations are included for LPG (annex 8) no specific regulations are included for CNG or for LNG. The conclusion can be drawn that safety regulations for CNG/LNG combustion heaters should be added to ECE Regulation No.122 with the adoption and amendment of R.110. This should be brought to the attention of the Working Party on General Safety Provisions (GRSG) and WP.29.

Justification proposal 1

Heading

11. To prevent misinterpretation that subsection 9.2.4.3 does not apply to containments for LPG and CNG the words "Fuel containers" are introduced. Fuel container is used in UN ECE Regulations 67 (LPG) and 110 (CNG) for the containment of LPG and CNG instead of "fuel tank". We are of the opinion that fuel containers provide equal safety to LNG fuel tanks but this was not part of the supportive information provided and the urge to regulate the use of LNG for ADR 2015.

9.2.4.3 (a)

12. Subsection 9.2.4.3 (a) requires that leaking fuel "shall drain to the ground". This is not possible for gaseous fuels which are lighter than air. As such this requirement prevents the use of gaseous fuels.

13. It cannot be prevented that leaking fuel will contact hot parts of the vehicle or of the load in any position, (e.g. when on its side or completely overturned, nose-up/nose-down). Therefore the wording "normal operating conditions" in plural are included. It means the vehicle shall be on its wheels, either with the engine running or not, level or sideways banked/uphill/downhill etc.

14. However, the basic performance requirement that leaking fuel shall not come into contact with hot parts of the engine, exhaust or load should remain and be applicable to all fuels (in the normal operating conditions of the vehicle).

9.2.4.3 (b), (c) and (d):

15. To define which types of fuel tanks are allowed to be used and which are not a reference to ECE Regulation 34 (further R.34) for liquid fuels is introduced, a reference to R.110 for LNG in (c) and wording that fuel containers for LPG and CNG are not to be used.

16. In the new (c) additional requirements to R.110 are introduced for the discharge of by the safety valve. LNG fuel tanks have two pressure relief valves, one primary relief valve for the boil down and a secondary for emergencies. The discharge from the primary relief valve discharges through a vent stack which shall extend to a high level away from hot engine or load parts. The primary relief valve and venting stack will also cope with most of the discharge due to a temperature-, pressure rise due to a loss of vacuum of the insulation of the fuel tank.

Justification proposal 2

17. An amendment is proposed to remain in keeping with the original intention of this subsection. Dual-fuel systems on the market today, combining diesel and a gas with a compression ignition engine may otherwise be used. The gas is only added under certain engine running conditions. The flashpoint of LPG or natural gas is significantly lower than the flashpoint of diesel.

18. For the future it should be discussed if the limitation to a compression-ignition engine is justified, as well from the point of the flashpoint of the fuel and the risk of state-of-art positive ignition systems.

Justification proposal 3

19. Vehicles fitted with fuel tanks according to ECE Regulation R.34 shall be accepted for registration of a vehicle, but other fuel tanks may be accepted. Although R.34 gives minimum safety requirements for tanks it was never mandatory for vehicles of Chapter 9.1 of ADR. For this reason a transitional measure is proposed.

20. Some vehicles are already equipped with LNG fuel systems based on national rules. Approval of the fuel tanks may not include the markings of R.110 but may have the same level of safety. If a same level of safety can be proven, of up-dated to the safe level these vehicles can continued to be used.

General justification

Safety:	See above.
Feasibility:	Transporters and heavy goods vehicles manufacturers will have the option to have LNG fuelled vehicles approved for the carriage of dangerous goods. Harmonized safety requirements which will be available help the approval authorities with the approval.
Enforceability:	No specific problems fore seen.